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Memo

date: *January 13, 2014*

to: *RSC*

from: *D. Beavis*

subject: *ERL Roof Transition*

The initial design of the ERL roof was at a fixed height of 13 feet above the floor. To aid in rigging operations the central section of the roof was raised to 14 feet forming a transition at both end of the area. To examine the impact of this change on radiation dose through the roof a simple model was used in MCNPX[1].

A target of cooper was placed at z=0 with the roof transition at z=200 cm. The roof over the target is at y=300cm and after the transition the roof is at 270cm. In both areas the roof is 120cm thick and composed of light concrete. The copper target is 10cm long and 1.5 cm in radius. The model has rotation symmetry about the z-axis to simplify the calculations. Figure 1 show the zx view of the geometry.

[1] MCNPX version 2.7C was used for the analysis. D. PELOWITZ (ed.), "MCNPX User's Manual", Version 2.7.0, Los Alamos National Laboratory, LA-CP-11-00438 (2011).

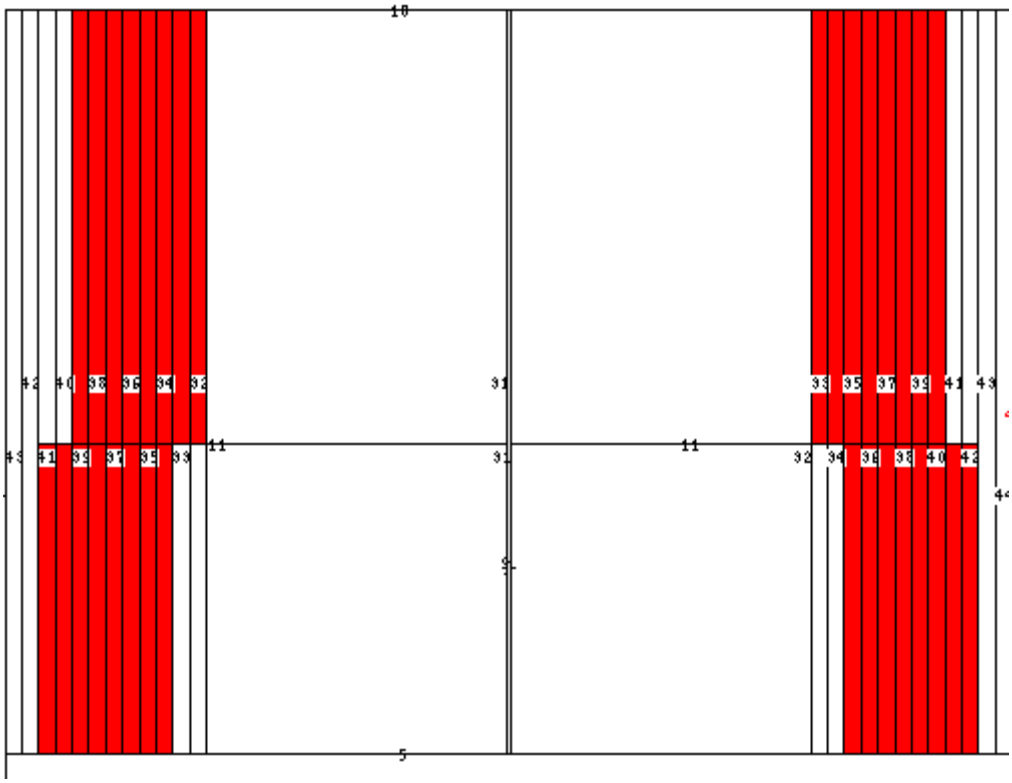

Figure 1: Model used to simulate ERL roof transition.

A pencil beam of electrons was transported into the target and the electrons and photons tracked. The production of neutrons was ignored in this treatment. The side wall was divided into 15cm layers to allow for changing the importance factors as a function of depth in the concrete. Fluence to dose conversions factors were used to tally the dose per electron at different depths in the concrete and as a function of z. The results for two radii are displayed in Figure 2. The radius of 390 cm corresponds to the top of the roof section before z=200 cm. The dose per electron (blue squares) is consistent with a distribution for three feet of light concrete except for a minor change related to the geometry change at z=200. The dose per electron (green circles) at a radius of 390 cm is consistent with the distribution for four feet of light concrete with a sharp rise near the transition, where it sees effectively one foot less of concrete.

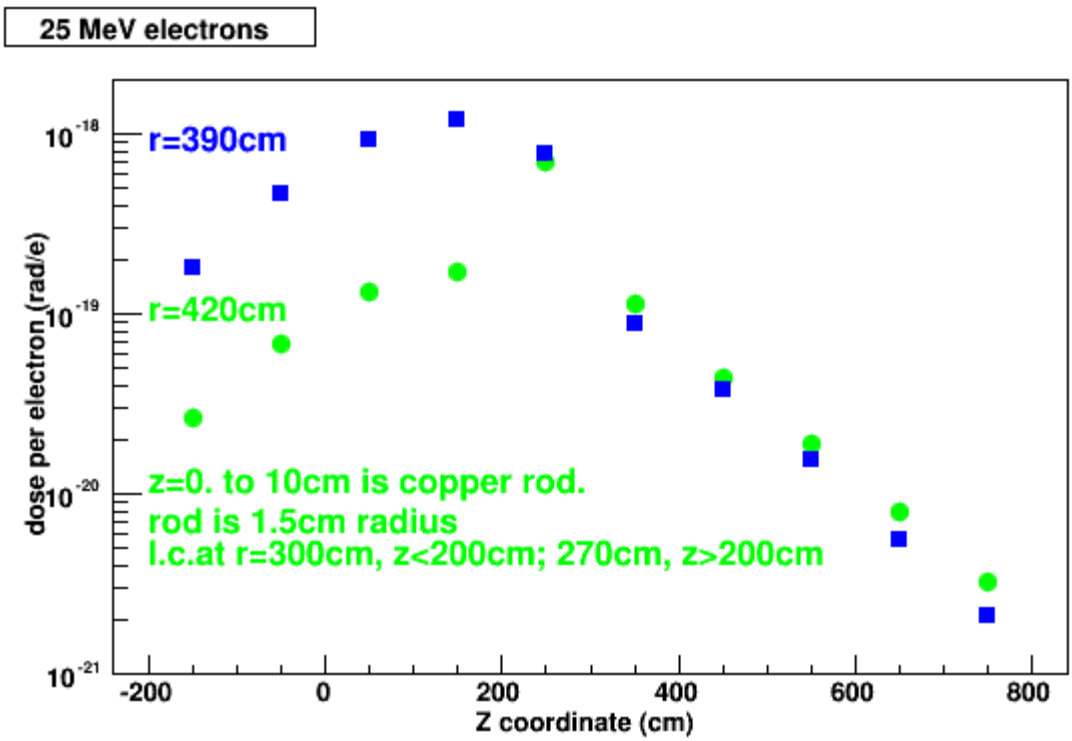

Figure 2: Dose per electron at radii of 290 cm and 320 cm. The roof transition occurs at z=200.

The dose rate through the roof and at the transition is dependent on the beam power on the target. Ten Watts of beam power corresponds to $9*10^{16}$ and $9*10^{*15}$ e/hr for energies 2.5 MeV and 25 MeV, respectively. Point detectors were also used in the analysis and were used to get a slightly higher dose than the flux average over a distance of a meter. The dose rates near the transition for 10 Watts of electron beam are 0.006 mrem/hr and 7.1 mrem/hr for energies of 2.5 MeV and 25 MeV respectively. Access to the roof is not allowed when the Gun or Five-Cell Cavity are being operated. There are some large cracks between the roof beams that form the roof. The dose rates out these cracks could be as high as 1.1 rem/hr (2.5 MeV) and 5.8 rem/hr (25 MeV) if the entire source can shine directly through the crack. Although the actual dose rates are expected to be smaller and not represent whole body exposure they are still a serious concern if personnel access the roof.

The dose rate as a function of depth was tallied and can be used to examine the effective attenuation of the shielding. The results for 2.5 and 25 MeV electrons are shown in Figure 3 for the bin 100cm<z<200cm, where the peak of the dose distribution occurs. The lines in the plot are eyeball fits ignoring the first point. The corresponding TVLs are 36 cm and 20 cm for 25 MeV and 2.5 MeV respectively. These results can be used to extrapolate to thicker shields if required.

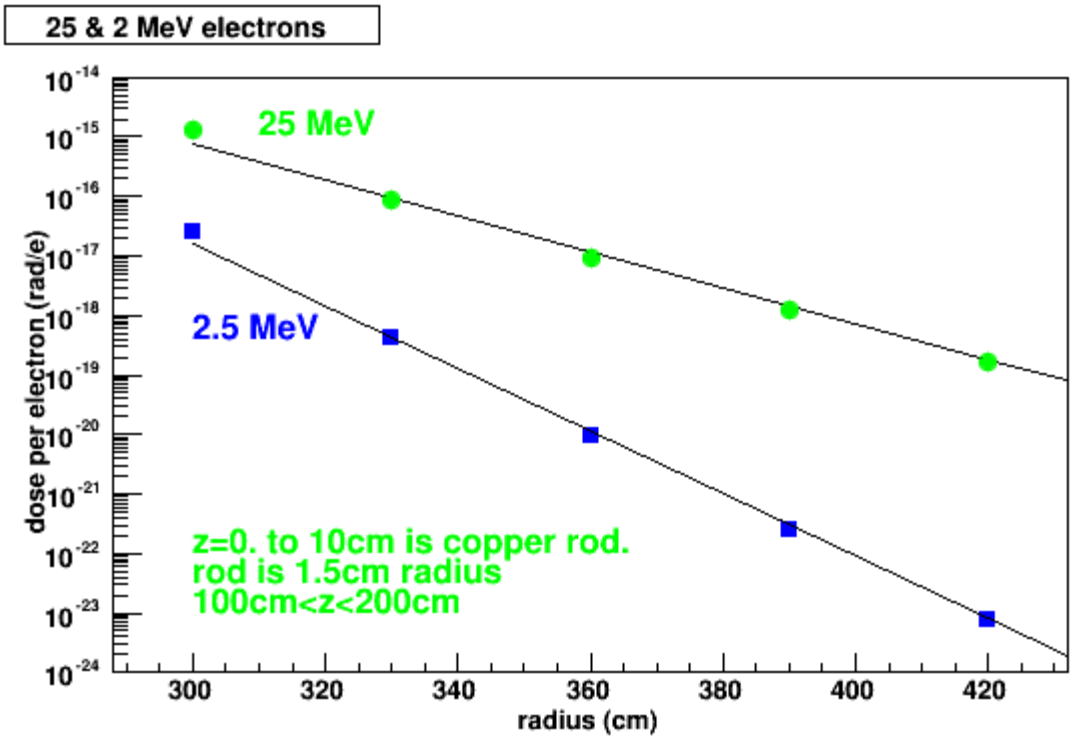

Figure 3: The photon dose through the roof light concrete for 2.5 MeV (blue squares) and 25 MeV (green circles) striking a copper rod. The concrete begins at a radius of 300 cm.

The roof transition appears to produce a localized elevated dose rate consistent with three feet of effective shielding. The dose rates for the 10W test are not an issue for the transition. The radiation hazards from other weaknesses such as the cracks or the roof ODH vent are probably more relevant concerns if someone accesses the roof. For higher power tests in the future it will be important to correlate the dose rates at the chipmunks to the dose rate on the roof including the weak locations.

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